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ABSTRACT

This curriculum guide, the fourth in a set of six, contains teacher and student materials for a unit on mechanical engineering prepared as part of a seventh- and eighth-grade agricultural science curriculum that is integrated with science instruction. The guide contains the state goals and sample learning objectives for each goal for students in grades 8-10 and a teacher presentation outline for the unit. The unit, which begins by listing the agricultural practices and science concepts to be taught, along with activities and applications, contains the following components: teaching steps, lesson outlines, teacher's presentation outlines for each day, student information guide, terms and definitions, worksheets, student activity note sheets, student activity information sheets, student activity record sheets, quizzes, practice problems, and 12 transparency masters. Teacher's activity sheets and tests have answers provided. The unit covers the following topics: (1) selection of the best horticultural or agricultural tool for a job and (2) agricultural mechanics. (KC)

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7th and 8th Grade Agriculture Science Curriculum

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Teacher Materials

Mechanical Advantage

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MECHANICAL ADVANTAGE
BIOLOGICAL AND PHYSICAL SCIENCES
STATE GOAL FOR LEARNING 1

As a result of their schooling, students will have a working knowledge of the concepts and basic vocabulary of biological, physical and contemporary technological society.

SAMPLE LEARNING OBJECTIVES FOR GOAL 1

By the end of GRADE 8, students should be able to:

O1. Demonstrate how forces move objects.
O2. Understand the uses and advantages of simple machines.
O3. Relate forces to motion and work.

By the end of GRADE 10, students should be able to:

O2. Understand force, work, and power.
O3. Relate the resulting movement of an object to the forces applied.

STATE GOAL FOR LEARNING 3

As a result of their schooling, students will have a working knowledge of the principles of scientific research and their application in simple research projects.

SAMPLE LEARNING OBJECTIVES FOR GOAL 3

By the end of GRADE 8, students should be able to:

A5. Demonstrate effective participation as a member of a laboratory group.
B2. Demonstrate alternative procedures for solving a problem.
B3. Understand the need to acquire, organize, and evaluate data.
B6. Relate a laboratory procedure that another student can follow.

By the end of GRADE 10, students should be able to:

B3. Demonstrate the ability to draw conclusions from collected data.

STATE GOAL FOR LEARNING 4

As a result of their schooling, students will have a working knowledge of the processes, techniques, methods, equipment and available technology of science.

SAMPLE LEARNING OBJECTIVES FOR GOAL 4

By the end of GRADE 8, students should be able to:

C1. Recognize an inference based upon experimental observation.

By the end of GRADE 10, students should be able to:

D1. Revise a prediction on the basis of additional data.

PHYSICAL DEVELOPMENT
STATE GOAL FOR LEARNING 3

As a result of their schooling, students will be able to understand consumer health and safety, including environmental health.

SAMPLE LEARNING OBJECTIVES FOR GOAL 3

By the end of GRADE 8, students should be able to:

A2. Perform with appropriate safety equipment in safe environments.
G1. Know safety procedures needed in schools and the home to prevent accidents.

By the end of GRADE 10, students should be able to:

A2. Perform with appropriate safety equipment in safe environments.

LANGUAGE ARTS
STATE GOAL FOR LEARNING 4

As a result of their schooling, students will be able to use spoken language effectively in formal and informal situations to communicate ideas and information and to ask and answer questions.

SAMPLE LEARNING OBJECTIVES FOR GOAL 4

By the end of GRADE 8, students should be able to:

C2. Distinguish among statements of observation, opinion, and judgment.

MATHEMATICS
STATE GOAL FOR LEARNING 1

As a result of their schooling, students will be able to perform the computations of addition, subtraction, multiplication, and division using whole numbers, integers, fractions, and decimals.

SAMPLE LEARNING OBJECTIVES FOR GOAL 1

By the end of GRADE 8, students should be able to:

B3. Add and subtract integers.
B4. Multiply and divide integers with and without a calculator.
H4. Read diagrams, flowcharts, and schematics.

STATE GOAL FOR LEARNING 4

As a result of their schooling, students will be able to identify, analyze and solve problems using algebraic equations, inequalities, functions and their graphs.

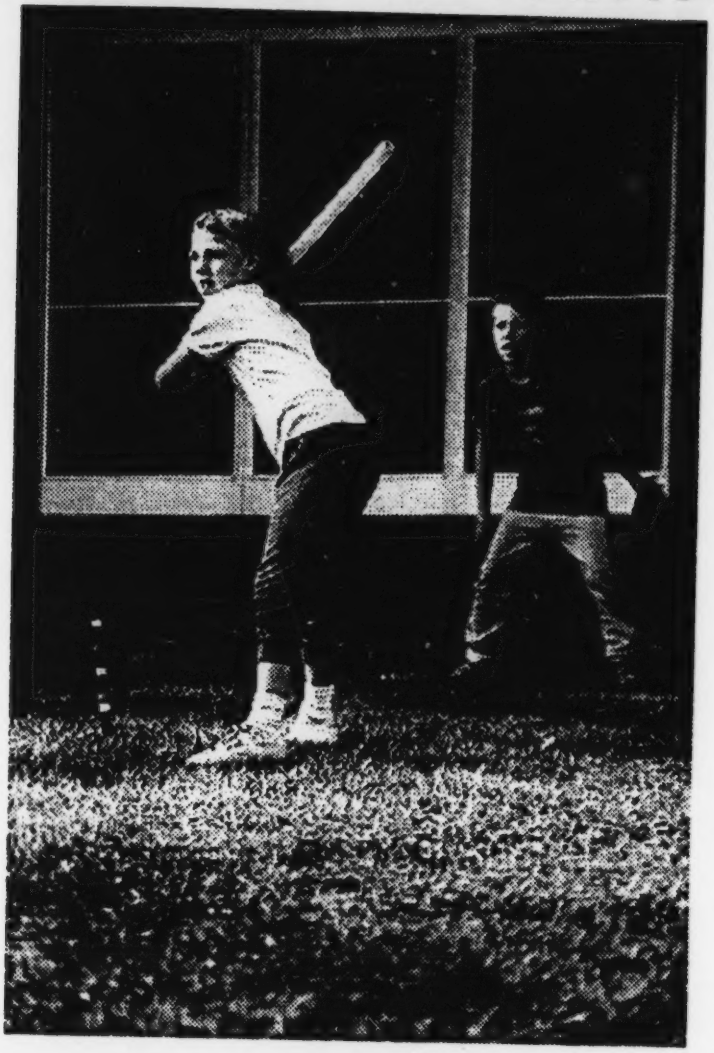
SAMPLE LEARNING OBJECTIVES FOR GOAL 4

By the end of GRADE 8, students should be able to:

B2. Solve one-step equations.
D2. Solve for a variable in a simple formula when given values for all other variables.
D3. Use values from a real situation for the variables in a formula and solve.

By the end of GRADE 10, students should be able to:
F4. Multiply binomials.

MECHANICAL ADVANTAGE



TEACHER PRESENTATION OUTLINE

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MECHANICAL ADVANTAGE OF SIMPLE MACHINES

AGRICULTURAL PRACTICES

Selection of best horticultural or agricultural tool for the job
Agricultural Mechanics

SCIENCE CONCEPTS

Classification of Simple Machines
Calculating Mechanical Advantage

AGRICULTURAL APPLICATIONS FOR 7&8TH GRADE PHYSICAL SCIENCES:

UNIT TITLES:	ACTIVITIES & APPLICATIONS
Mechanical Advantage	Tools for landscaping; pg. 4 Tools for greenhouse worker; pg. 6

TEACHING STEPS

(for teacher to follow)

A. Materials Provided in Teaching Kit:

1/2 OPEN/CLOSED END wrenches
1/2 bolt, & lock washer
1/2 nuts

B. Additional Materials Needed for Student Activities:

ruler or yardstick

C. Lesson Outline

D. Teacher's Presentation Outline

E. Audio Visual Materials:

1. SIMPLE MACHINES
2. SIX TYPES OF SIMPLE MACHINES
3. INCLINED PLANE
4. WEDGE
5. SCREW
6. LEVER
7. WHEEL AND AXLE
8. PULLEY
9. MECHANICAL ADVANTAGE
10. MECHANICAL ADVANTAGE OF INCLINED PLANE
11. MECHANICAL ADVANTAGE OF LEVER
12. MECHANICAL ADVANTAGE OF WHEEL & AXLE.

F. Student Handouts and Quizzes

Student Information Guide
Work Sheet A
Work Sheet B
Work Sheet C
Work Sheet D
Student Activity Note Sheet
Student Activity - 1 Information Sheet
Student Activity - 2 Information Sheet
Student Activity Record Sheet
Quiz 1

LESSON OUTLINE:

Day 1:

Discussion of Attention Step/Problem Statement.
Explanation of General Information about Simple Machines.
Assignment of Student Information Guide on Mechanical Advantage of Simple Machines
Student Completion of Work Sheet A during class.
Explanation of Scientific Terms.
Student Completion of Work Sheet B during class or as homework.
Individual Study using Computer Study Guide.

Day 2:

Discussion of Scientific Terms Work Sheet (Work Sheet B).
Demonstration of Comparison of Effort Required to Tighten a Bolt With & Without a Simple Machine.
Student Activity of Comparison of Effort Required to Tighten a Bolt With & Without a Simple Machine.
Assignment of Part A of Student Activity - 1 Record Sheet.
Individual Study using Computer Study Guide.

Day 3:

Discussion of Part A of Student Activity - 1 Record Sheet.
Student Completion of Quiz 1.
Explanation of Mechanical Advantage.
Student Completion of Part B of Student Activity - 1 Record Sheet.
Individual Evaluation using Computer Study Guide.

Day 4:

Student Completion of Work Sheet C during class.
Review of information on Simple Machines and Mechanical Advantage.
Individual Evaluation using Computer Quiz.

Day 5:

Student Completion of Work Sheet D during class.
Individual Evaluation using Computer Quiz.
Student Completion of Quiz 2.

THE MECHANICAL ADVANTAGE OF SIMPLE MACHINES

TEACHER'S PRESENTATION OUTLINE

DAY 1

Teaching Note: ***Discuss the Attention Step/Problem Statement with the class.***

ATTENTION STEP/PROBLEM STATEMENT
Simple machines are mechanical devises that help us work everyday. They enable us to do our work quicker, more efficiently, and help us accomplish things that we normally could not do by ourselves.

Have students brainstorm as a class about the types of simple machines that are needed to do landscape gardening around a home or office building.

Student responses will vary, but may include:
rake, shovel, spading fork, hoe, hand trowel, bulb planter, hand cultivator, wheelbarrow, knives, pruning shears, ax, saw, hammer, screwdriver, turf edger, post hole digger, etc.

Next, have students brainstorm on how simple machines make tasks easier. Student responses will vary. The teacher should lead the class discussion or introduce the concept that simple machines aid in doing work by changing the amount or direction of force that is applied to an object.

OBJECTIVES:

KNOWLEDGE OBJECTIVES:

Students will know:

- definition of work
- definition of mechanical advantage
- 6 types of simple machines
- description of the 6 types of simple machines
- how to figure mechanical advantage when using simple machines

PERFORMANCE OBJECTIVES:

Students will:

- compare effort required to tighten a bolt with and without a simple machine
- figure the mechanical advantage of a wrench
- identify several simple machines
- figure the mechanical advantage of several simple machines

THE MECHANICAL ADVANTAGE OF SIMPLE MACHINES

Teaching Note: ***Explain the following general information about simple machines to the class.***

GENERAL INFORMATION ABOUT SIMPLE MACHINES

Lecture Note: Use overhead # 1 (SIMPLE MACHINES).

- In scientific terms, the term "work" means to apply force to an object in order to move it. Simple machines are mechanical devises that help people do work everyday. They help us do work by changing the size or direction of the forces used in doing work.

Lecture Note: Use overhead # 2 (SIX TYPES OF SIMPLE MACHINES).

- There are six types of simple machines. The six types of machines include: inclined plane, wedge, screw, lever, pulley, and wheel & axle. They are all used frequently in everyday life and in many jobs.

Lecture Note: Use overhead # 3 (INCLINED PLANE).

- An inclined plane is simply a ramp that is used to move heavy objects up and down. It helps us do work by decreasing the amount of effort needed to move heavy objects. When an inclined plane is used, objects are moved a further distance, but with less effort. For example, a greenhouse worker may use an inclined plane to load a delivery truck with plants and flowers. By using an inclined plane, the greenhouse worker moves the plants onto the truck with less effort than if each box of plants had to be lifted onto the truck from the ground.

Lecture Note: Use overhead # 4 (WEDGE).

- A wedge is an inclined plane that moves. Most wedges are made up of two inclined planes. The wedge is then moved through a material. Force is applied to the thick end of the wedge to drive the thin edge of the wedge through a material to cut it. The sides of the wedge push the material apart with a greater force than the force used at the thick end of the wedge. Many cutting tools are examples of wedges. Examples of wedges are knives or pruning shears that are being used to harvest flowers from a plant. The knife blade moves through the plant stem, pushes the stem apart, and makes the cut.

Lecture Note: Use overhead # 5 (SCREW).

- A screw is an inclined plane that is found on a cylinder. You can think of a screw as a ramp that winds around that cylinder. By turning the screw with a screwdriver, the screw moves in or out of a material. It takes very little effort to turn the screw, but it takes a lot of turns to move the screw a very small distance into a material. The screw can hold a much greater load than the force used to turn it. Our same greenhouse worker might use screws on supports that hold the flowers in place on a greenhouse bench. The supports keep the flowers growing straight and are adjusted as the flowers grow. The screws are loosened so the supports can be moved, and then they are tightened again.

Lecture Note: Use overhead # 6 (LEVER).

- A lever is a simple machine that is found in many horticultural tools, household tools and kitchen gadgets. Levers are used to do work by having a straight part that moves when force is applied and a part that does not move. The part that does not move is called a fulcrum. Levers help us do work either by increasing the effort that is applied or by changing the direction of the force. Examples of levers might include a spading fork which is a first class lever, and a wheelbarrow which is a second class lever, and a rake which is a third-class lever. All three have a part that moves and a fulcrum. However, the fulcrum is arranged on each lever differently. A greenhouse worker might use any of these levers on the job. A wheelbarrow could be used to move media (soil) to fill greenhouse benches, a spading fork could be used to loosen the media, and a rake could be used to smooth and level the media in the benches.

Lecture Note: Use overhead # 7 (WHEEL AND AXLE).

- The wheel and axle is a simple machine made up of two circles that move together. The wheel and axle are really a form of a lever that moves in a circle. The smaller circle, or axle, acts like a fulcrum. The wheel is the larger circle. A steering wheel on a greenhouse delivery truck is an example of a wheel and axle. The steering wheel is the wheel while the steering wheel shaft acts as the axle. When a person is driving a truck, the axle moves when the steering wheel is turned. The outer edge of the steering wheel moves around a greater distance than the smaller axle. Since the wheel and axle is really a lever, the amount of force achieved is greater than the force a person applies to the wheel. Another example of a wheel an axle is a screwdriver.

Lecture Note: Use overhead # 8 (PULLEY).

- A pulley is a lever that rotates around a fixed point. Pulleys can either change the direction of the force that is applied or increase the force that is applied to achieve a mechanical advantage. A movable pulley, such as a block and tackle is needed to achieve mechanical advantage.

Teaching Note: ***Assign Work Sheet A and Student Information Guide on Mechanical Advantage of Simple Machines. Students can complete Work Sheet A either individually or in small groups during class time.***

STUDENT INFORMATION GUIDE

THE MECHANICAL ADVANTAGE OF SIMPLE MACHINES

In scientific terms, the term "work" means to apply force to an object in order to move it. Simple machines are mechanical devises that help people do work everyday. They help us do work by changing the size or direction of the forces used in doing work. Simple machines consist of only one part.

All machines require energy to do work. Simple machines differ from complicated machines, such as a truck, on their energy source. A complicated machine may get its energy from a motor. Usually, the energy that is needed to use simple machines, such as a rake, come from the person using the rake.

Simple machines aid in doing work by changing the amount or direction of force that is applied to an object. Most machines use the principle of applying force over a wide area to get a large force over a small area.

There are six types of simple machines. The six types of machines include: inclined plane, wedge, screw, lever, pulley, and wheel & axle. They are all used frequently in everyday life and in many jobs.

An inclined plane is simply a ramp that is used to move heavy objects up and down. It helps us do work by decreasing the amount of effort needed to move heavy objects. When an inclined plane is used, objects are moved a further distance, but with less effort. For example, a greenhouse worker may use an inclined plane to load a delivery truck with plants and flowers. By using an incline plane, the greenhouse worker moves the plants onto the truck with less effort than if each box of plants had to be lifted onto the truck from the ground.

A wedge is an inclined plane that moves. Most wedges are made up of two inclined planes. The wedge is then moved through a material. Force is applied to the thick end of the wedge to drive the thin edge of the wedge through a material to cut it. The sides of the wedge push the material apart with a greater force than the force used at the thick end of the wedge. Many cutting tools are examples of wedges. An example of a wedge is a knife

or pruning shears that are being used to harvest flowers from a plant. The knife blade moves through the plant stem, pushes the stem apart, and makes the cut.

A screw is an inclined plane that is found on a cylinder. You can think of a screw as a ramp that winds around that cylinder. By turning the screw with a screwdriver, the screw moves in or out of a material. It takes very little effort to turn the screw, but it takes a lot of turns to move the screw a very small distance into a material. The screw can hold a much greater load than the force used to turn it. Our greenhouse worker might use screws on supports that hold the flowers in place on a greenhouse bench. The supports keep the flowers growing straight and are adjusted as the flowers grow. The screws are loosened so the supports can be moved, and then they are tightened again.

A lever is a simple machine that is found in many horticultural tools, household tools and kitchen gadgets. Levers are used to do work by having a straight part that moves when force is applied and a part that does not move. The part that does not move is called a fulcrum. Levers help us do work either by increasing the effort that is applied or by changing the direction of the force. Examples of levers might include a spading fork which is a first class lever, and a wheelbarrow which is a second class lever, and a rake which is a third-class lever. All three have a part that moves and a fulcrum. However, the fulcrum is arranged on each lever differently. A greenhouse worker might use any of these levers on the job. A wheelbarrow could be used to move media (soil) to fill greenhouse benches, a spading fork could be used to loosen the media, and a rake could be used to smooth and level the media in the benches.

The wheel and axle is a simple machine made up of two circles that move together. The wheel and axle are really a form of a lever that moves in a circle. The smaller circle, or axle, acts like a fulcrum. The wheel is the larger circle. A steering wheel on a greenhouse delivery truck is an example of a wheel and axle. The steering wheel is the wheel while the steering wheel shaft acts as the axle. When a person is driving a truck, the axle moves when the steering wheel is turned. The outer edge of the steering wheel moves around a greater distance than the smaller axle. Since the wheel and axle is really a lever, the amount of force achieved is greater than the force a person applies to the wheel. Another example of a wheel an axle is a screwdriver.

A pulley is a lever that rotates around a fixed point. Pulleys can either change the direction of the force that is applied or increase the force that is applied to achieve a mechanical advantage. A movable pulley, such as a

block and tackle is needed to achieve mechanical advantage.

Machines make it easier to do work. Just how much easier, depends on the machine and the load. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called the mechanical advantage. To figure the mechanical advantage of a machine mathematically, divide the machine's force by the effort force that someone applies to a machine. In general terms:

MECHANICAL ADVANTAGE = MACHINE FORCE divided by EFFORT FORCE

The mechanical advantage of a machine does not change the amount of force that must be applied to the machine. If a machine has a mechanical advantage of 2, then it would have a machine force two times greater than the effort force. By using the machine, the job would be two times easier. Only 1/2 of the force would have to be applied get the job done. If a machine has a mechanical advantage of 4, then it would have a machine force four times greater than the effort force. By using the machine, the job would be four times easier or require 1/4 the force to do the job.

To figure the mechanical advantage of a machine, first the machine needs to be classified as one of the simple machines we have discussed: inclined plane, wedge, screw, lever, wheel and axle, or pulley.

To determine the mechanical advantage of using an inclined plane to load boxes of plants into a truck, use the formula:

MECHANICAL ADVANTAGE = EFFORT DISTANCE divided by LOAD DISTANCE

The effort distance is the length of the inclined plane while the load distance is the height of the inclined plane. If the boards used as an inclined plane are 8 feet long and the distance from the back of the truck to the ground was 4 feet, the mechanical advantage would be:
M. A. = E / L
M. A. = 8 ft / 4 ft
M. A. = 2

When using a lever, two forces are involved. The effort force is the force that is applied by the person moving the lever. The resistance force is the mass (weight) of the object that needs to be moved or due to friction.

The resistance arm is the length of the lever between the resistance force and the fulcrum. The effort arm is the length of the lever from the fulcrum to where the effort force is applied.

To determine the mechanical advantage of using a lever, use the formula:

MECHANICAL ADVANTAGE = LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

To determine the mechanical advantage of a wheel & axle simple machine, use the formula:

MECHANICAL ADVANTAGE =
RADIUS OF THE WHEEL
divided by RADIUS OF THE AXLE

For example, if the steering wheel on a truck has a radius of 24 inches and the radius of the axle is 2 inches, the Mechanical Advantage of the wheel and axle is 12.

M.A. = RW / RA

M.A. = 24 / 2

M.A. = 12

SOME SCIENTIFIC TERMS TO REMEMBER:

effort arm -	the length of the lever from the fulcrum to where the effort force is applied.
effort force -	the amount of effort a person must exert while moving an object
fulcrum -	the part that does not move on a lever when it is doing work
inclined plane -	a ramp which is a type of simple machine
levers -	a type of simple machine that has a part that moves and a part that does not move while doing work
mechanical advantage -	the comparison of the force that the machine applies to an object compared to the force a person applies to the machine
pulleys -	a type of simple machine that can be classified as a lever that rotates around a fixed point
resistance arm -	the length of the lever between the resistance force and the fulcrum.
resistance force -	the mass (weight) of the object that needs to be moved or friction.

screw - a type of simple machine that can be classified as an inclined plane on a cylinder

simple machines - mechanical devises that help people do work by changing the size or direction of the forces used in doing work

wedge - a type of simple machine that can be classified as an inclined plane that moves

wheel and axle - a type of simple machine that can be classified as a lever that moves in a circle

work - the act of applying force to an object in order to move it.

WORK SHEET A

DIRECTIONS: Complete the following questions.

1. The six types of simple machines are:
   a. inclined plane *d. lever*

   b. wedge *e. wheel and axle*

   c. screw *f. pulley*

2. In scientific terms, the term "work" means to apply force to an object in order to ***move*** it.

3. All machines require ***energy*** to do work.

4. Simple machines aid in doing work by changing the ***amount*** or ***direction*** of force that is applied to an object.

5. Most machines use the principle of applying force over a wide area to get a large force over a ***small*** area.

6. Usually, the energy that is needed to use simple machines, such as a rake, come from the ***person*** using the rake.

7. When an inclined plane is used to move objects, objects are moved a further distance, and with ***less*** effort.

8. Levers have a straight part that moves when force is applied and a ***fulcrum***, which is the part that does not move when force is applied.

9. Levers help us do work either by ***increasing*** the effort that is applied or by changing the ***direction*** of the force.

10. A wedge and a screw are really types of an ***inclined plane,*** while the wheel & axle and pulley are variations of the ***lever.***

Teaching Note: ***Explain the following terms to the class and then assign Work Sheet B. The Students can find the definitions for these terms in the Student Information Guide. Students can complete Work sheet B during class or as homework.***

GLOSSARY OF SCIENTIFIC TERMS:

effort arm -	the length of the lever from the fulcrum to where the effort force is applied.
effort force -	the amount of effort a person must exert while moving an object
fulcrum -	the part that does not move on a lever when it is doing work
inclined plane -	a ramp which is a type of simple machine
levers -	a type of simple machine that has a part that moves and a part that does not move while doing work
mechanical advantage -	the comparison of the force that the machine applies to an object compared to the force a person applies to the machine
pulleys -	a type of simple machine that can be classified as a lever that rotates around a fixed point
resistance arm -	the length of the lever between the resistance force and the fulcrum.
resistance force -	the mass (weight) of the object that needs to be moved or friction.

screw -	a type of simple machine that can be classified as an inclined plane on a cylinder
simple machines -	mechanical devises that help people do work by changing the size or direction of the forces used in doing work
wedge -	a type of simple machine that can be classified as an inclined plane that moves
wheel and axle -	a type of simple machine that can be classified as a lever that moves in a circle
work -	the act of applying force to an object in order to move it.

WORK SHEET B

Directions: The answers to the following fill-in-the blank questions are terms which have something to do with the Mechanical Advantage of Simple Machines. Choose the term from the word list below that best answers each question. Each term may be used only once.

Word List:

effort arm	effort force
fulcrum	inclined plane
lever	mechanical advantage
pulleys	resistance arm
resistance force	screw
simple machines	wedge
wheel & axle	work

Fill-in-the blank:

1. *Work* is the act of applying force to an object in order to move it.

2. A type of simple machine that has a part that moves and a part that does not move while doing work is called a *lever*.

3. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called *mechanical advantage.*

4. The *effort arm* is the length of the lever from the fulcrum to where the effort force is applied.

5. The amount of effort a person must exert while moving an object is called *effort force*.

6. *Simple Machines* are mechanical devises that help people do work by changing the size or direction of the forces used in doing work.

7. The *fulcrum* is the part that does not move on a lever when it is doing work.

8. The *wheel and axle* is a type of simple machine that can be classified as a lever that moves in a circle.

9. Another name for a ramp could be an *inclined plane.* machine

10. The *resistance arm* is the length of the lever between the resistance force and the fulcrum.

11. A *wedge* can be classified as an inclined plane that moves.

12. *Pulleys* are a type of simple machine that can be classified as a lever that rotates around a fixed point.

13. A type of simple machine that can be classified as an inclined plane on a cylinder is a *screw.*

14. *Resistance Force* is the mass (weight) of the object that needs to be moved or friction.

Teaching Note: *The students may use the Mechanical Advantage of Simple Machines Study Guide Computer Program for individual study and review for this lesson.*

Day 2:

Teaching Note: *Discuss the Scientific Terms Work Sheet (Work Sheet B) with the class.*

Teaching Note: *Demonstrate "Comparison of Effort Required to Tighten a Bolt With & Without a Simple Machine" activity. Students can take notes and record them on the Student Activity Sheet during the teacher demonstration. The steps and procedures are found in the Student Activity - 1 Information Sheet, "Comparison of Effort Required to Tighten a Bolt With & Without a Simple Machine". The activity and demonstration steps are summarized below.*

Activity Summary: *Students should work in groups of 1 - 4 students. They will tighten a nut onto a bolt by hand and then with a wrench. Then they will try to loosen the bolt, first by hand, and then using the wrench. Students should find it easier to tighten & loosen the bolt using the wrench. A variation of this activity could involve the tightening and loosening of the bolt using different size wrenches. After this has been completed the students will measure length of the wrench. Students should complete Part A of Student Activity - 1 Record Sheet during the activity. Part B will be completed on DAY 3.*

Teaching Note: *Assign and discuss Student Activity - 1 Information Sheet, "Comparison of Effort Required to Tighten a Bolt With & Without a Simple Machine". Provide the students with supplies for the student activity and answer any questions. Coordinate the Student Activity.*

Teaching Note: *After the activity, students may use the Mechanical Advantage of Simple Machines Study Guide Computer Program for individual study and review for this lesson.*

STUDENT ACTIVITY

NOTE SHEET

List steps to follow:

1. TIGHTEN BOLT BY HAND
2. TIGHTEN BOLT WITH THE WRENCH
3. LOOSEN THE BOLT BY HAND
4. LOOSEN THE BOLT WITH THE WRENCH
5. COMPARE THE DIFFERENCE IN EFFORT
6. MAKE MEASUREMENTS AND RECORD THEM

STUDENT ACTIVITY - 1
INFORMATION SHEET

COMPARISON OF EFFORT REQUIRED TO TIGHTEN A BOLT WITH & WITHOUT A SIMPLE MACHINE

a. **Purpose:** To demonstrate how simple machines

b. **What each group of students need:**
1 1/2 OPEN/CLOSED END Wrenches
1 1/2 Bolt
2 1/2 Nuts
ruler

c. **Here's How:**

1. Work in your assigned group.

2. Get wrench, bolt and nuts from your teacher.

3. One person in your group needs to tighten the nut onto the bolt as tight as possible.

4. Pass the nut and bolt around the group. Everyone in the group should try to tighten the nut onto the bolt.

5. Now using the wrench, try to tighten the nut again. Everyone in the group should try to tighten the nut onto the bolt using the wrench.

6. Next try to loosen the nut from the bolt by hand. Everyone in the group should try to loosen the bolt.

7. Now try to loosen the nut using the wrench. How much easier is it to turn the nut using the wrench?

8. Measure the wrench, the diameter of the nut, and your arm from your fingers to your elbow, and from your fingers to your shoulders. Record the measurements in Part A of the Student Activity - 1 Record Sheet.

9. Complete Part A of the Student Activity - 1 Record Sheet.

10. Clean up your work area.

STUDENT ACTIVITY - 1
RECORD SHEET

PART A. DATA & QUESTIONS

1. MEASUREMENTS:
   Wrench -
   Diameter of the nut -
   Your arm from your fingers to your elbow -
   Your arm from your fingers to your shoulders -

2. How does a wrench do work?

3. What type of simple machine is the wrench? Why? (Be able to defend your answer.)

PART B. FIGURING THE MECHANICAL ADVANTAGE

1. What type of simple machine is the wrench?

2. What is the formula for calculating mechanical advantage for this simple machine?

3. Calculate the mechanical advantage of using the wrench. (Show your work.)

Day 3

Teaching Note: ***Discuss Student Activity - 1 "Comparison of Effort Required to tighten a bolt with & without a Simple Machine" with the class.***

Teaching Note: ***Quiz 1 can be used to evaluate student's knowledge of the Mechanical Advantage of Simple Machines.***

QUIZ 1

A: MATCHING:

_b_ 1. wedge		a. type of lever
_a_ 2. wheel & axle		b. type of inclined plane
_a_ 3. pulley		
_b_ 4. screw		

B: TRUE OR FALSE:

_T_ 5. In scientific terms, the term "work" means to apply force to an object in order to move it.

_T_ 6. Simple machines are mechanical devises that help us do work by changing the size or direction of the forces used in doing work.

C: FILL-IN-THE BLANK:

7. All machines require ***energy*** to do work.

8. An ***inclined plane*** is simply a ramp that is used to move heavy objects up and down.

9. ***Levers*** are used to do work by having a straight part that moves when force is applied and a part that does not move.

D: SHORT ANSWER:

10. What principle do most simple machines use to aid us in doing work?

Most machines use the principle of applying force over a wide area to get a large force over a small area.

Teaching Note: ***Explain the following information about mechanical advantage to the class.***

Lecture Note: ***Use overhead #9 (MECHANICAL ADVANTAGE).***

- Machines make it easier to do work. Just how much easier, depends on the machine and the load. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called the mechanical advantage. To figure the mechanical advantage of a machine mathematically, divide the machine's force by the effort force that someone applies to a machine. In general terms:

MECHANICAL ADVANTAGE = MACHINE FORCE divided by EFFORT FORCE

- The mechanical advantage of a machine does not change the amount of force that must be applied to the machine. If a machine has a mechanical advantage of 2, then it would have a machine force two times greater than the effort force. By using the machine, the job would be two times easier. Only 1/2 of the force would have to be applied get the job done. If a machine has a mechanical advantage of 4, then it would have a machine force four times greater than the effort force. By using the machine, the job would be four times easier or require 1/4 the force to do the job.

- To figure the mechanical advantage of a machine, first the machine needs to be classified as one of the simple machines we have discussed: inclined plane, wedge, screw, lever, wheel and axle, or pulley.

Lecture Note: ***Use overhead #10 (MECHANICAL ADVANTAGE OF INCLINED PLANE).***

- To determine the mechanical advantage of using an inclined plane to load boxes of plants into a truck, use the formula:

MECHANICAL ADVANTAGE = EFFORT DISTANCE (length) divided by LOAD DISTANCE (height)

The effort distance is the length of the inclined plane while the load distance is the height of the inclined plane. If the boards used as an inclined plane are 8 feet long and the distance from the back of the truck to the ground was 4 feet, the mechanical advantage would be:

M. A. = E / L

M. A. = 8 ft / 4 ft. =

M. A. = 2

Lecture Note: ***Use overhead #11 (MECHANICAL ADVANTAGE OF LEVERS).***

- When using a lever, two forces are involved. The effort force is the force that is applied by the person moving the lever. The resistance force is the mass (weight) of the object that needs to be moved or due to friction.

- The resistance arm is the length of the lever between the resistance force and the fulcrum. The effort arm is the length of the lever from the fulcrum to where the effort force is applied.

- To determine the mechanical advantage of using a lever, use the formula:

MECHANICAL ADVANTAGE =
LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

Lecture Note: ***Use overhead #12 (MECHANICAL ADVANTAGE OF WHEEL & AXLE).***

To determine the mechanical advantage of a wheel & axle simple machine, use the formula:

MECHANICAL ADVANTAGE =
RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE

For example, if the steering wheel on a truck has a radius of 24 inches and the radius of the axle is 2 inches, the Mechanical Advantage of the wheel and axle is 12.

M.A. = RW / RA

M.A. = 24 / 2

M.A. = 12

Teaching Note: ***Assign Part B of Student Activity - 1 Record Sheet to the class. This*** should be completed during class time. Discuss the answers to Part B with each group.

Teaching Note: ***The students may use the Mechanical Advantage of Simple Machines Study Guide Computer Program for individual study and review of this lesson.***

Day 4

Teaching Note: Assign Work Sheet C to the class. Students can complete Work Sheet C either in class or as homework.

WORK SHEET C

DIRECTIONS: Complete the following questions.

A. Fill - in - the Blank:

1. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called the *mechanical advantage.*

2. To figure the mechanical advantage of a machine mathematically, divide the machine's force by the *effort force* that someone applies to a machine.

3. If a machine has a mechanical advantage of 2, then it would have a machine force *two* times greater than the effort force.

4. To determine the mechanical advantage of using an inclined plane to load boxes of plants into a truck, use the formula:

MECHANICAL ADVANTAGE = EFFORT DISTANCE (length) divided by LOAD DISTANCE (height)

The effort distance is the length of the inclined plane while the load distance is the height of the inclined plane. If the boards used as an inclined plane are 10 feet long and the distance from the back of the truck to the ground was 5 feet, the mechanical advantage would be:

M. A. = E / L

M. A. = *2*

5. When using a lever, two forces are involved. The *effort force* is the force that is applied by the person moving the lever. The *resistance force* is the mass (weight) of the object that needs to be moved or due to friction.

6. The *resistance arm* is the length of the lever between the resistance force and the fulcrum. The *effort arm* is the length of the lever from the fulcrum to where the effort force is applied.

7. To determine the mechanical advantage of using a spading fork that has a 4 foot handle and the tines of the fork are 12 inches .Use the formula:

MECHANICAL ADVANTAGE =
LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

M. A. = EA / RA

M. A. = 4 / 1

M. A. = *4*

8. To determine the mechanical advantage of a wheel & axle simple machine, use the formula:

MECHANICAL ADVANTAGE =
RADIUS OF THE *WHEEL* divided by RADIUS OF THE *AXLE.*

9. If the steering wheel on a tractor has a radius of 30 inches and the radius of the axle is 3 inches, the Mechanical Advantage of the wheel and axle is *10.*

10. The degree to which machines make it easier to do work depends on the *machine* and the load.

Teaching Note: ***Review information about Mechanical Advantage of Simple Machines with students. Some key facts are listed below:***

Teacher Review:

- In scientific terms, the term "work" means to apply force to an object in order to move it.

- Simple machines are mechanical devises that help people do work by changing the size or direction of the forces used in doing work. Simple machines consist of only one part.

- All machines require energy to do work. Usually, the energy that is needed to use a simple machine, such as a rake, come from the person using the rake.

- Simple machines aid in doing work by changing the amount or direction of force that is applied to an object. Most machines use the principle of applying force over a wide area to get a large force over a small area.

- There are six types of simple machines. The six types of machines include: inclined plane, wedge, screw, lever, pulley, and wheel & axle. They are all used frequently in everyday life and in many jobs.

- An inclined plane is simply a ramp that is used to move heavy objects up and down. It helps us do work by decreasing the amount of effort needed to move heavy objects. When an inclined plane is used, objects are moved a further distance, but with less effort.

- A wedge is an inclined plane that moves. Most wedges are made up of two inclined planes. The wedge is then moved through a material.

- A screw is an inclined plane that is found on a cylinder.

- Levers are used to do work by having a straight part that moves when force is applied and a part that does not move. The part that does not move is called a fulcrum. Levers help us do work either by increasing the effort that is applied or by changing the direction of the force.

- The wheel and axle is a simple machine made up of two circles that move together. The wheel and axle are really a form of a lever that moves in a circle. The smaller circle, or axle, acts like a fulcrum. The wheel is the larger circle.

- A pulley is a lever that rotates around a fixed point. Pulleys can either change the direction of the force that is applied or increase the force that is applied to achieve a mechanical advantage.

- Machines make it easier to do work. Just how much easier, depends on the machine and the load. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called the mechanical advantage. To figure the mechanical advantage of a machine mathematically, divide the machine's force by the effort force that someone applies to a machine. In general terms:

MECHANICAL ADVANTAGE = MACHINE FORCE divided by EFFORT FORCE

- The mechanical advantage of a machine does not change the amount of force that must be applied to the machine. If a machine has a mechanical advantage of 2, then it would have a machine force two times greater than the effort force. By using the machine, the job would be two times easier. Only 1/2 of the force would have to be applied get the job done.

- To figure the mechanical advantage of a machine, first the machine needs to be classified as one of the simple machines we have discussed: inclined plane, wedge, screw, lever, wheel and axle, or pulley.

- To determine the mechanical advantage of using an inclined plane to load boxes of plants into a truck, use the formula:

MECHANICAL ADVANTAGE = EFFORT DISTANCE divided by LOAD DISTANCE

- The effort distance is the length of the inclined plane while the load distance is the height of the inclined plane.

- When using a lever, two forces are involved. The effort force is the force that is applied by the person moving the lever. The resistance force is the mass (weight) of the object that needs to be moved or due to friction.

- The resistance arm is the length of the lever between the resistance force and the fulcrum. The effort arm is the length of the lever from the fulcrum to where the effort force is applied.

- To determine the mechanical advantage of using a lever, use the formula:

MECHANICAL ADVANTAGE =
LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

To determine the mechanical advantage of a wheel & axle simple machine, use the formula:

MECHANICAL ADVANTAGE =
RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE

Teaching Note: ***The students may use the Mechanical Advantage of Simple Machines Computer Quiz for individual evaluation.***

Day 5:

Teaching Note: ***Students should complete Work Sheet D: Student Review during class time.***

WORK SHEET D: STUDENT REVIEW

1. What are simple machines and how do they work?

   Simple machines are mechanical devises that help people do work by changing the size or direction of the forces used in doing work. Simple machines consist of only one part.

2. What principle of applying force do most simple machines use?

   Most machines use the principle of applying force over a wide area to get a large force over a small area.

3. How do inclined planes and levers work?
   1. *An inclined plane is a ramp that is used to move heavy objects up and down. It helps us do work by decreasing the amount of effort needed to move heavy objects. When an inclined plane is used, objects are moved a further distance, but with less effort.*

   2. *Levers are used to do work by having a straight part that moves when force is applied and a part that does not move. The part that does not move is called a fulcrum. Levers help us do work either by increasing the effort that is applied or by changing the direction of the force.*

4. What is meant by the term mechanical advantage?

   The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called the mechanical advantage.

5. How do you figure the mechanical advantage of a machine mathematically?

   MECHANICAL ADVANTAGE = MACHINE FORCE divided by EFFORT FORCE

6. What formula would you use to determine the mechanical advantage of using an inclined plane to load a lawnmower onto a truck?

MECHANICAL ADVANTAGE = EFFORT DISTANCE divided by LOAD DISTANCE

7. What is the mechanical advantage of using a 6 foot inclined plane to load a lawnmower 2 feet onto a truck?

M. A. = ED / LD

M. A. = 6 / 2

M. A. = 3

8. Describe the two forces involved in using a lever.

When using a lever, two forces are involved. The effort force is the force that is applied by the person moving the lever. The resistance force is the mass (weight) of the object that needs to be moved or due to friction.

9. What is the mechanical advantage of using a screwdriver to pry off a lid to a can of whitewash, if the length of the effort arm is 9 inches and the length of the resistance arm is 1 inch?

M. A. = EA / RA

M. A. = 9 / 1

M. A. = 9

10. Determine the mechanical advantage of a cart that has a 12 inch steering wheel & 1 inch axle, using the formula:

MECHANICAL ADVANTAGE =
RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE.

M. A. = RW / RA

M. A. = 12 / 1

M. A. = 12

Teaching Note: ***The students may use the Mechanical Advantage of Simple Machines Computer Quiz for individual evaluation.***

Teaching Note: ***Quiz 2 can be used to evaluate student's knowledge of the Mechanical Advantage of Simple Machines.***

QUIZ 2

A: MATCHING:

_c_ 1.	mechanical advantage of a lever	a.	RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE.
_b_ 2.	mechanical advantage of an inclined plane	b.	EFFORT DISTANCE divided by LOAD DISTANCE
_a_ 3.	mechanical advantage of a wheel & axle	c.	LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

B: PROBLEMS:

4. What is the mechanical advantage of using a 9 foot inclined plane to load a lawnmower 3 feet onto a truck?

   M. A. = ED / LD

   M. A. = 9 / 3

   M. A. = 3

5. Determine the mechanical advantage of a ventilation crank in the greenhouse that has a 12 inch steering wheel & 2 inch axle, using the formula:

   MECHANICAL ADVANTAGE =
   RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE.

   M. A. = RW / RA

   M. A. = 12 / 2

   M. A. = 6

E: AUDIO VISUAL MATERIALS:

OH1. SIMPLE MACHINES
OH2. SIX TYPES OF SIMPLE MACHINES

OH3. INCLINED PLANE
OH4. WEDGE

OH5. SCREW
OH6. LEVER

OH7. WHEEL AND AXLE
OH8. PULLEY

OH9. MECHANICAL ADVANTAGE
OH10. MECHANICAL ADVANTAGE OF INCLINED PLANE

OH11. MECHANICAL ADVANTAGE OF LEVER

OH12. MECHANICAL ADVANTAGE OF WHEEL & AXLE

OH1

SIMPLE MACHINES

1. MECHANICAL DEVISES THAT HELP US DO WORK

2. CHANGE THE SIZE OR DIRECTION OF FORCE THAT IS APPLIED TO AN OBJECT

3. USE PRINCIPLE OF APPLYING FORCE OVER A WIDE AREA TO GET A LARGE FORCE OVER A SMALL AREA

OH2

SIX TYPES OF SIMPLE MACHINES

1. INCLINED PLANE

2. WEDGE

3. SCREW

4. LEVER

5. WHEEL & AXLE

6. PULLEY

OH3

INCLINED PLANE

RAMP

DECREASES THE EFFORT FORCE REQUIRED BY A PERSON TO MOVE AN OBJECT

INCREASES THE EFFORT DISTANCE REQUIRED BY A PERSON TO MOVE AN OBJECT

OH4

WEDGE

INCLINED PLANE THAT MOVES

1. DECREASES THE EFFORT FORCE REQUIRED BY A PERSON TO CUT THROUGH AN OBJECT. (THE FORCE WHICH THE WEDGE CUTS APART AN OBJECT IS GREATER THAN FORCE APPLIED TO THE THICK END OF THE WEDGE.)

2. INCREASES THE EFFORT DISTANCE REQUIRED BY A PERSON TO CUT THROUGH AN OBJECT.

OH5

SCREW

INCLINED PLANE ON A CYLINDER

1. DECREASES THE EFFORT FORCE REQUIRED BY A PERSON
   (VERY LITTLE EFFORT IS NEEDED TO TURN THE SCREW INTO AN OBJECT WITH A SCREWDRIVER.)

2. INCREASES THE EFFORT DISTANCE REQUIRED BY A PERSON
   (BECAUSE A SCREW HAS MANY THREADS THAT WIND AROUND THE SCREW THE EFFORT DISTANCE IS INCREASED BY PERSON TURNING THE SCREW.)

OH6

LEVER

A. MADE UP OF 2 PARTS

1. PART THAT MOVES WHEN DOING WORK

2. FULCRUM - THE PART THAT DOES NOT MOVE WHEN DOING WORK

B. INCREASES THE EFFORT APPLIED OR CHANGES THE DIRECTION OF THE FORCE

OH7

WHEEL AND AXLE

A. MADE UP OF TWO CIRCLES THAT MOVE TOGETHER

B. FORM OF A LEVER THAT MOVES IN A CIRCLE

   1. AXLE ACTS AS A FULCRUM

   2. WHEEL IS THE LARGER CIRCLE THAT MOVES

C. INCREASES THE EFFORT APPLIED TO AN OBJECT

OH8

PULLEY

A. LEVER THAT ROTATES AROUND A FIXED POINT

B. INCREASES THE EFFORT APPLIED OR CHANGES THE DIRECTION OF THE FORCE.

OH9

MECHANICAL ADVANTAGE

MECHANICAL ADVANTAGE = MACHINE FORCE divided by EFFORT FORCE

DOES NOT CHANGE THE AMOUNT OF FORCE THAT MUST BE APPLIED TO THE MACHINE

A MECHANICAL ADVANTAGE OF 2 MEANS THE MACHINE FORCE IS TWO TIMES GREATER THAN THE EFFORT FORCE.

BY USING THE MACHINE, THE JOB WOULD BE TWO TIMES EASIER. ONLY 1/2 OF THE FORCE WOULD HAVE TO BE APPLIED TO GET THE JOB DONE.

OH10

MECHANICAL ADVANTAGE OF AN INCLINED PLANE

MECHANICAL ADVANTAGE =
EFFORT DISTANCE divided by LOAD DISTANCE
(length) (height)

EX.

M. A. = E / L

M. A. = 8 ft / 4 ft. =

M. A. = 2

OH11

MECHANICAL ADVANTAGE OF LEVERS

MECHANICAL ADVANTAGE =
LENGTH OF EFFORT ARM divided by
LENGTH OF RESISTANCE ARM

The effort arm is the length of the lever from the fulcrum to where the effort force is applied.

The resistance arm is the length of the lever between the resistance force and the fulcrum.

OH12

MECHANICAL ADVANTAGE OF WHEEL AND AXLE

MECHANICAL ADVANTAGE =
RADIUS OF THE WHEEL divided by
RADIUS OF THE AXLE

For example, if the steering wheel on a truck has a radius of 24 inches and the radius of the axle is 2 inches, the Mechanical Advantage of the wheel and axle is 12.

M.A. = RW / RA

M.A. = 24 / 2

M.A. = 12

F. STUDENT HANDOUTS AND QUIZZES

Student Information Guide

Work Sheet A

Work Sheet B

Work Sheet C

Work Sheet D

Student Activity Note Sheet

Student Activity - 1 Information Sheet

Student Activity - 1 Record Sheet

Student Activity - 2 Information Sheet

Quiz 1

Quiz 2

STUDENT INFORMATION GUIDE

THE MECHANICAL ADVANTAGE OF SIMPLE MACHINES

In scientific terms, the term "work" means to apply force to an object in order to move it. Simple machines are mechanical devises that help people do work everyday. They help us do work by changing the size or direction of the forces used in doing work. Simple machines consist of only one part.

All machines require energy to do work. Simple machines differ from complicated machines, such as a truck, on their energy source. A complicated machine may get its energy from a motor. Usually, the energy that is needed to use simple machines, such as a rake, come from the person using the rake.

Simple machines aid in doing work by changing the amount or direction of force that is applied to an object. Most machines use the principle of applying force over a wide area to get a large force over a small area.

There are six types of simple machines. The six types of machines include: inclined plane, wedge, screw, lever, pulley, and wheel & axle. They are all used frequently in everyday life and in many jobs.

An inclined plane is simply a ramp that is used to move heavy objects up and down. It helps us do work by decreasing the amount of effort needed to move heavy objects. When an inclined plane is used, objects are moved a further distance, but with less effort. For example, a greenhouse worker may use an inclined plane to load a delivery truck with plants and flowers. By using an incline plane, the greenhouse worker moves the plants onto the truck with less effort than if each box of plants had to be lifted onto the truck from the ground.

A wedge is an inclined plane that moves. Most wedges are made up of two inclined planes. The wedge is then moved through a material. Force is applied to the thick end of the wedge to drive the thin edge of the wedge through a material to cut it. The sides of the wedge push the material apart with a greater force than the force used at the thick end of the wedge. Many cutting tools are examples of wedges. An example of a wedge is a knife

or pruning shears that are being used to harvest flowers from a plant. The knife blade moves through the plant stem, pushes the stem apart, and makes the cut.

A screw is an inclined plane that is found on a cylinder. You can think of a screw as a ramp that winds around that cylinder. By turning the screw with a screwdriver, the screw moves in or out of a material. It takes very little effort to turn the screw, but it takes a lot of turns to move the screw a very small distance into a material. The screw can hold a much greater load than the force used to turn it. Our greenhouse worker might use screws on supports that hold the flowers in place on a greenhouse bench. The supports keep the flowers growing straight and are adjusted as the flowers grow. The screws are loosened so the supports can be moved, and then they are tightened again.

A lever is a simple machine that is found in many horticultural tools, household tools and kitchen gadgets. Levers are used to do work by having a straight part that moves when force is applied and a part that does not move. The part that does not move is called a fulcrum. Levers help us do work either by increasing the effort that is applied or by changing the direction of the force. Examples of levers might include a spading fork which is a first class lever, and a wheelbarrow which is a second class lever, and a rake which is a third-class lever. All three have a part that moves and a fulcrum. However, the fulcrum is arranged on each lever differently. A greenhouse worker might use any of these levers on the job. A wheelbarrow could be used to move media (soil) to fill greenhouse benches, a spading fork could be used to loosen the media, and a rake could be used to smooth and level the media in the benches.

The wheel and axle is a simple machine made up of two circles that move together. The wheel and axle are really a form of a lever that moves in a circle. The smaller circle, or axle, acts like a fulcrum. The wheel is the larger circle. A steering wheel on a greenhouse delivery truck is an example of a wheel and axle. The steering wheel is the wheel while the steering wheel shaft acts as the axle. When a person is driving a truck, the axle moves when the steering wheel is turned. The outer edge of the steering wheel moves around a greater distance than the smaller axle. Since the wheel and axle is really a lever, the amount of force achieved is greater than the force a person applies to the wheel. Another example of a wheel an axle is a screwdriver.

A pulley is a lever that rotates around a fixed point. Pulleys can either change the direction of the force that is applied or increase the force that is applied to achieve a mechanical advantage. A movable pulley, such as a

block and tackle is needed to achieve mechanical advantage.

Machines make it easier to do work. Just how much easier, depends on the machine and the load. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called the mechanical advantage. To figure the mechanical advantage of a machine mathematically, divide the machine's force by the effort force that someone applies to a machine. In general terms:

MECHANICAL ADVANTAGE = MACHINE FORCE divided by EFFORT FORCE

The mechanical advantage of a machine does not change the amount of force that must be applied to the machine. If a machine has a mechanical advantage of 2, then it would have a machine force two times greater than the effort force. By using the machine, the job would be two times easier. Only 1/2 of the force would have to be applied get the job done. If a machine has a mechanical advantage of 4, then it would have a machine force four times greater than the effort force. By using the machine, the job would be four times easier or require 1/4 the force to do the job.

To figure the mechanical advantage of a machine, first the machine needs to be classified as one of the simple machines we have discussed: inclined plane, wedge, screw, lever, wheel and axle, or pulley.

To determine the mechanical advantage of using an inclined plane to load boxes of plants into a truck, use the formula:

MECHANICAL ADVANTAGE = EFFORT DISTANCE divided by LOAD DISTANCE

The effort distance is the length of the inclined plane while the load distance is the height of the inclined plane. If the boards used as an inclined plane are 8 feet long and the distance from the back of the truck to the ground was 4 feet, the mechanical advantage would be:
M. A. = E / L
M. A. = 8 ft / 4 ft
M. A. = 2

When using a lever, two forces are involved. The effort force is the force that is applied by the person moving the lever. The resistance force is the mass (weight) of the object that needs to be moved or due to friction.

The resistance arm is the length of the lever between the resistance force and the fulcrum. The effort arm is the length of the lever from the fulcrum to where the effort force is applied.

To determine the mechanical advantage of using a lever, use the formula:

MECHANICAL ADVANTAGE = LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

To determine the mechanical advantage of a wheel & axle simple machine, use the formula:

MECHANICAL ADVANTAGE = RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE

For example, if the steering wheel on a truck has a radius of 24 inches and the radius of the axle is 2 inches, the Mechanical Advantage of the wheel and axle is 12.

M.A. = RW / RA

M.A. = 24 / 2

M.A. = 12

SOME SCIENTIFIC TERMS TO REMEMBER:

effort arm -	the length of the lever from the fulcrum to where the effort force is applied.
effort force -	the amount of effort a person must exert while moving an object
fulcrum -	the part that does not move on a lever when it is doing work
inclined plane -	a ramp which is a type of simple machine
levers -	a type of simple machine that has a part that moves and a part that does not move while doing work
mechanical advantage -	the comparison of the force that the machine applies to an object compared to the force a person applies to the machine
pulleys -	a type of simple machine that can be classified as a lever that rotates around a fixed point
resistance arm -	the length of the lever between the resistance force and the fulcrum.
resistance force -	the mass (weight) of the object that needs to be moved or friction.

screw -	a type of simple machine that can be classified as an inclined plane on a cylinder
simple machines -	mechanical devises that help people do work by changing the size or direction of the forces used in doing work
wedge -	a type of simple machine that can be classified as an inclined plane that moves
wheel and axle -	a type of simple machine that can be classified as a lever that moves in a circle
work -	the act of applying force to an object in order to move it.

WORK SHEET A

DIRECTIONS: Complete the following questions.

1. The six types of simple machines are:
   a. *d.*

   b. *e.*

   c. *f.*

2. In scientific terms, the term "work" means to apply force to an object in order to ____ it.

3. All machines require _____ to do work.

4. Simple machines aid in doing work by changing the _____ or _____ of force that is applied to an object.

5. Most machines use the principle of applying force over a wide area to get a large force over a _____ area.

6. Usually, the energy that is needed to use simple machines, such as a rake, come from the _____ using the rake.

7. When an inclined plane is used to move objects, objects are moved a further distance, and with ____ effort.

8. Levers have a straight part that moves when force is applied and a _____, which is the part that does not move when force is applied.

9. Levers help us do work either by _____ the effort that is applied or by changing the _____ of the force.

10. A wedge and a screw are really types of an _____ while the wheel & axle and pulley are variations of the _____.

WORK SHEET B

Directions: The answers to the following fill-in-the blank questions are terms which have something to do with the Mechanical Advantage of Simple Machines. Choose the term from the word list below that best answers each question. Each term may be used only once.

Word List:

effort arm	effort force
fulcrum	inclined plane
lever	mechanical advantage
pulleys	resistance arm
resistance force	screw
simple machines	wedge
wheel & axle	work

Fill-in-the blank:

1. ____ is the act of applying force to an object in order to move it.

2. A type of simple machine that has a part that moves and a part that does not move while doing work is called a _____.

3. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called _____.

4. The _____ is the length of the lever from the fulcrum to where the effort force is applied.

5. The amount of effort a person must exert while moving an object is called _____.

6. _____ are mechanical devises that help people do work by changing the size or direction of the forces used in doing work.

7. The _____ is the part that does not move on a lever when it is doing work.

8. The _____ is a type of simple machine that can be classified as a lever that moves in a circle.

9. Another name for a ramp could be an _____ *machine.*

10. *The* _____ is the length of the lever between the resistance force and the fulcrum.

11. A _____ can be classified as an inclined plane that moves.

12. _____ are a type of simple machine that can be classified as a lever that rotates around a fixed point.

13. A type of simple machine that can be classified as an inclined plane on a cylinder is a ____.

14. _____ is the mass (weight) of the object that needs to be moved or friction.

WORK SHEET C

DIRECTIONS: Complete the following questions.

A. Fill - in - the Blank:

1. The comparison of the force that the machine applies to an object compared to the force a person applies to the machine is called the _____.

2. To figure the mechanical advantage of a machine mathematically, divide the machine's force by the _____ that someone applies to a machine.

3. If a machine has a mechanical advantage of 2, then it would have a machine force _____ times greater than the effort force.

4. To determine the mechanical advantage of using an inclined plane to load boxes of plants into a truck, use the formula:

MECHANICAL ADVANTAGE = EFFORT DISTANCE (length) divided by LOAD DISTANCE (height)

The effort distance is the length of the inclined plane while the load distance is the height of the inclined plane. If the boards used as an inclined plane are 10 feet long and the distance from the back of the truck to the ground was 5 feet, the mechanical advantage would be:

M. A. = E / L

M. A. = ____

5. When using a lever, two forces are involved. The _____ is the force that is applied by the person moving the lever. The _____ is the mass (weight) of the object that needs to be moved or due to friction.

6. The _____ is the length of the lever between the resistance force and the fulcrum. The _____ is the length of the lever from the fulcrum to where the effort force is applied.

7. To determine the mechanical advantage of using a spading fork that has a 4 foot handle and the tines of the fork are 12 inches .Use the formula:

MECHANICAL ADVANTAGE =
LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

M. A. = EA / RA

M. A. = 4 / 1

M. A. =_____

8. To determine the mechanical advantage of a wheel & axle simple machine, use the formula:

MECHANICAL ADVANTAGE =
RADIUS OF THE _____ divided by RADIUS OF THE ____.

9. If the steering wheel on a tractor has a radius of 30 inches and the radius of the axle is 3 inches, the Mechanical Advantage of the wheel and axle is ___.

10. The degree to which machines make it easier to do work depends on the _____ and the load.

WORK SHEET D: STUDENT REVIEW

1. What are simple machines and how do they work?

2. What principle of applying force do most simple machines use?

3. How do inclined planes and levers work?

4. What is meant by the term mechanical advantage?

5. How do you figure the mechanical advantage of a machine mathematically?

6. What formula would you use to determine the mechanical advantage of using an inclined plane to load a lawnmower onto a truck?

7. What is the mechanical advantage of using a 6 foot inclined plane to load a lawnmower 2 feet onto a truck?

M. A. = ED / LD

M. A. = 6 / 2

M. A. = ___

8. Describe the two forces involved in using a lever.

9. What is the mechanical advantage of using a screwdriver to pry off a lid to a can of whitewash, if the length of the effort arm is 9 inches and the length of the resistance arm is 1 inch?

M. A. = EA / RA

10. *Determine the mechanical advantage of a cart that has a 12 inch steering wheel & 1 inch axle, using the formula:*

MECHANICAL ADVANTAGE =
RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE.

STUDENT ACTIVITY

NOTE SHEET

List steps to follow:

1. TIGHTEN BOLT BY HAND
2. TIGHTEN BOLT WITH THE WRENCH
3. LOOSEN THE BOLT BY HAND
4. LOOSEN THE BOLT WITH THE WRENCH
5. COMPARE THE DIFFERENCE IN EFFORT
6. MAKE MEASUREMENTS AND RECORD THEM

STUDENT ACTIVITY - 1
INFORMATION SHEET

COMPARISON OF EFFORT REQUIRED TO TIGHTEN A BOLT WITH & WITHOUT A SIMPLE MACHINE

a. **Purpose:** To demonstrate how simple machines

b. **What each group of students need:**
1 1/2 OPEN/CLOSED END Wrenches
1 1/2 Bolt
2 1/2 Nuts
ruler

c. **Here's How:**

1. Work in your assigned group.

2. Get wrench, bolt and nuts from your teacher.

3. One person in your group needs to tighten the nut onto the bolt as tight as possible.

4. Pass the nut and bolt around the group. Everyone in the group should try to tighten the nut onto the bolt.

5. Now using the wrench, try to tighten the nut again. Everyone in the group should try to tighten the nut onto the bolt using the wrench.

6. Next try to loosen the nut from the bolt by hand. Everyone in the group should try to loosen the bolt.

7. Now try to loosen the nut using the wrench. How much easier is it to turn the nut using the wrench?

8. Measure the wrench, the diameter of the nut, and your arm from your fingers to your elbow, and from your fingers to your shoulders. Record the measurements in Part A of the Student Activity - 1 Record Sheet.

9. Complete Part A of the Student Activity - 1 Record Sheet.

10. Clean up your work area.

STUDENT ACTIVITY - 1
RECORD SHEET

PART A. DATA & QUESTIONS

1. MEASUREMENTS:
   Wrench -
   Diameter of the nut -
   Your arm from your fingers to your elbow -
   Your arm from your fingers to your shoulders -

2. How does a wrench do work?

3. What type of simple machine is the wrench? Why? (Be able to defend your answer.)

PART B. FIGURING THE MECHANICAL ADVANTAGE

1. What type of simple machine is the wrench?

2. What is the formula for calculating mechanical advantage for this simple machine?

3. Calculate the mechanical advantage of using the wrench. (Show your work.)

QUIZ 1

A: MATCHING:

_____1. wedge	a. type of lever
_____2. wheel & axle	b. type of inclined plane
_____3. pulley	
_____4. screw	

B: TRUE OR FALSE:

_____5. In scientific terms, the term "work" means to apply force to an object in order to move it.

_____6. Simple machines are mechanical devises that help us do work by changing the size or direction of the forces used in doing work.

C: FILL-IN-THE BLANK:

7. All machines require _____ to do work.

8. An _____ is simply a ramp that is used to move heavy objects up and down.

9. _____ are used to do work by having a straight part that moves when force is applied and a part that does not move.

D: SHORT ANSWER:

10. What principle do most simple machines use to aid us in doing work?

QUIZ 2

A: MATCHING:

_____1.	mechanical advantage of a lever	a.	RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE.
_____2.	mechanical advantage of an inclined plane	b.	EFFORT DISTANCE divided by LOAD DISTANCE
_____3.	mechanical advantage of a wheel & axle	c.	LENGTH OF EFFORT ARM divided by LENGTH OF RESISTANCE ARM

B: PROBLEMS:

4. What is the mechanical advantage of using a 9 foot inclined plane to load a lawnmower 3 feet onto a truck?

   M. A. = ED / LD

   M. A. = 9 / 3

   M. A. = ___

5. Determine the mechanical advantage of a ventilation crank in the greenhouse that has a 12 inch steering wheel & 2 inch axle, using the formula:

   MECHANICAL ADVANTAGE =
   RADIUS OF THE WHEEL divided by RADIUS OF THE AXLE.

   M. A. = RW / RA

   M. A. = 12 / 2

   M. A. =___